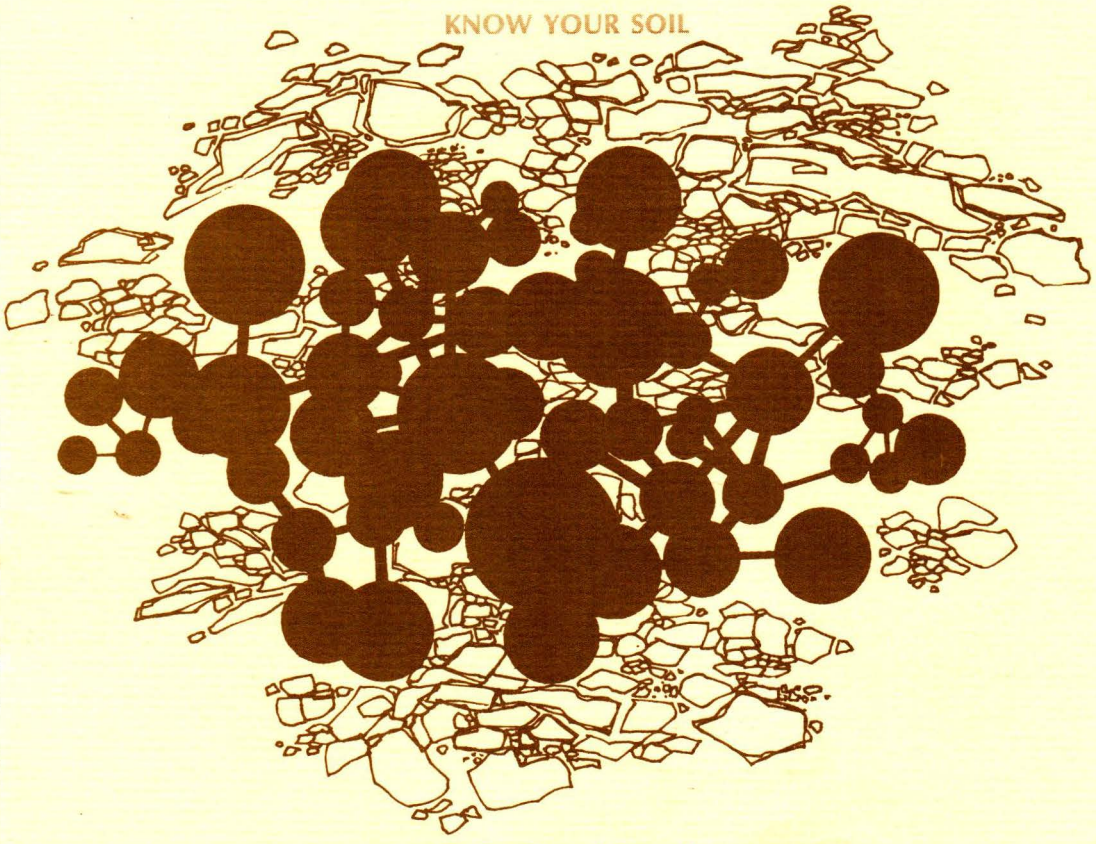
Have the Soil Tested



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Have the Soil Tested

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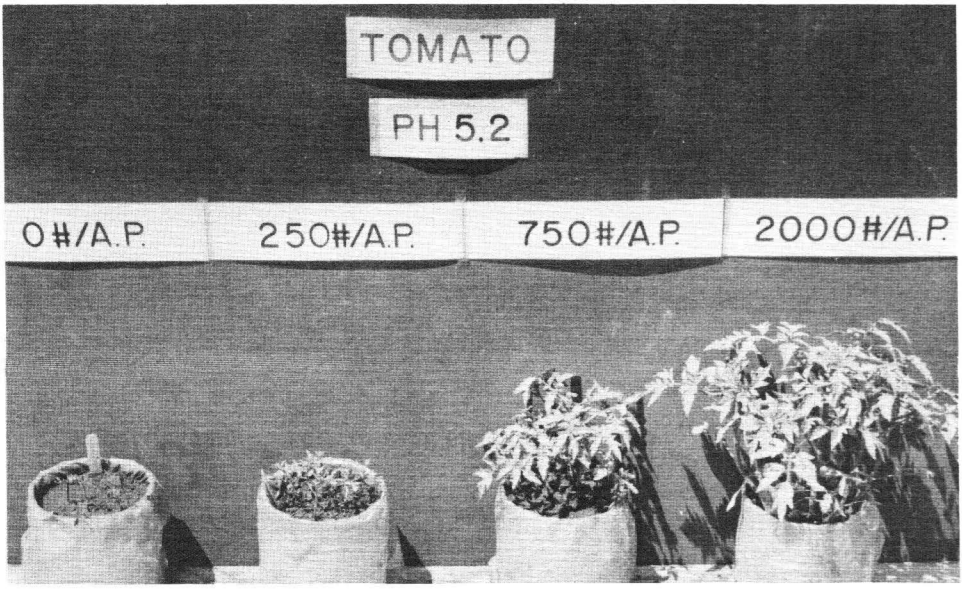
Maintaining or increasing the productivity of soils by methods which are economically sound continues to be a major problem of farmers and growers. Poor quality, low yields, and even total crop failure may result from the deficiency in soils of one or more of the mineral elements. Visual examination of the soil may tell a great deal but no one can look at the soil, feel it, and determine its needs for lime and fertilizers to enhance plant growth.

Methods to determine lime and fertilizer needed in soils may be grouped as follows: (1) field plot tests, (2) pot tests, (3) plant analysis, (4) nutrient deficiency symptoms, and (5) soil analysis. Any one of these may be used to determine plant needs. Best results are usually obtained when a combination of two or more are used.

Field plot tests are used to determine plant response on a specific soil under a controlled set of conditions. These are considered the most accurate method of determining fertility needs for a given crop on a given soil. Shown above is the response of sugar cane to added phosphorus on the Kapaa soil on Kauai.

Field Plot Tests

Field plot tests are used for specific crops on specific soils. Certain controlled conditions are established in the field plot and plant response to these conditions is determined. Treatments are replicated and are designed to show the differences among the treatments applied. This method determines the plant response under the conditions of the experiment. The results are generally valid for the same crop grown under the same conditions on the same soil. These experiments should be conducted over a period of years and represent the most accurate method of determining fertility practices. The major disadvantage of this method is the long period of time required to conduct the experiments, analyze the results, and make the results available to those who need them. Their accuracy is limited to the particular crop and soil used in the experiment. However, since many soils of the same soil family in Hawaii are very similar in nature, these results may be applied to them with satisfactory results. The individual farmer can use this method on his own fields if he leaves a check or an untreated strip in his field to determine the effect of a particular practice under his own conditions. When this is done the check strip should omit only one factor of treatment to prevent confusion of the results.



Pot tests are similar to field plot tests. The treatment area is smaller and greater control over many variables is possible. This pot test shows the response of tomatoes to different levels of phosphorus fertilizer at pH 5.2.

Pot Tests

Pot tests are similar to field plot tests. A much smaller volume of soil is used for testing. This method requires less space to obtain test results. The soil, or other growing medium, is placed in pots or other containers instead of used in the field. This type of experimental work provides a greater degree of control over the many variable factors of environment, and it generally leads to results more quickly than field testing. To test plant responses, treatments are varied, as in field plot tests. However, the results obtained are not necessarily applicable directly to field conditions. The time required to obtain results is relatively long. This method may be used in conjunction with field plot testing to reduce the overall time required to obtain experimental results. It may also be used in conjunction with other testing methods to verify results or to increase the accuracy of the method.

Plant Analysis

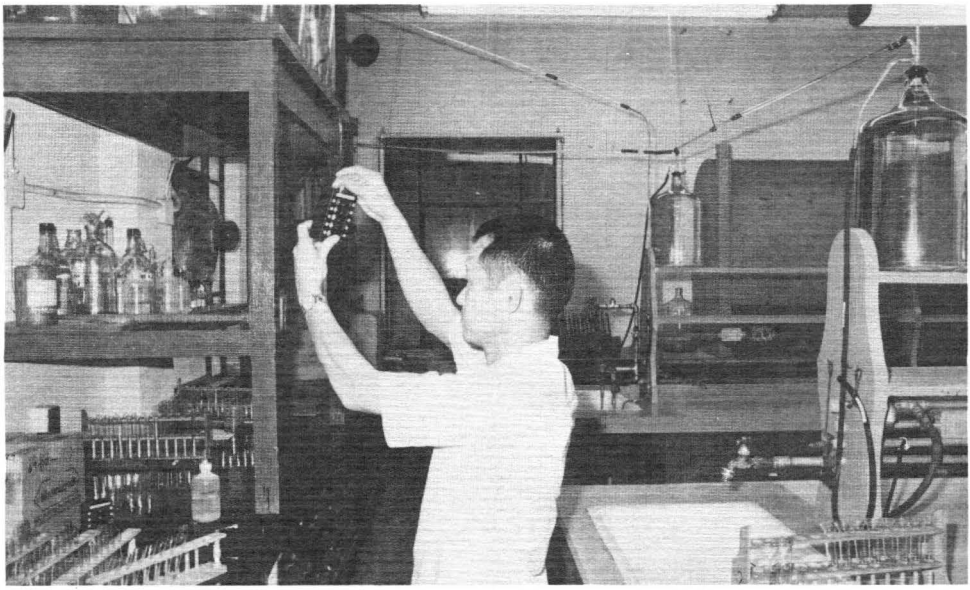
Plant analysis determines the total amount of one or more elements in the plant. All or certain parts of the plant are collected and analyzed to determine the levels of the different elements stored in the plant tissue. These may be analyzed by chemical means or chemical-mechanical means. Chemical analysis has little meaning unless the results are related to plant growth so that reliable data for de-

A spectrophotometer used for both soil and plant analysis. This equipment represents the latest development for analytical work.

termining plant needs are obtained. Fertilizer materials may then be added or withheld to obtain the desired plant response. The "crop logging" system utilizéd by some sugar plantations is an example of the use of plant anaylsis in Hawaii.

Tissue testing is another form of plant analysis. This system uses the liquid pressed out of fresh plant tissue, or extracts the soluble plant nutrients in the tissue, with water. The level of nutrients in the plant indicates the needs of the plant. As normally used, this method is not as precise as plant anaylsis. It may serve as a guide to the status of the plant at the time the sample is taken. Plant samples must be tested immediately after they are taken because the value of the test decreases with time as the plant material dehydrates. This method, popular in some areas of the United States, may be of value in a crop management program where quick decisions must be made.

The two methods of plant analysis described above determine the level of nutrients in the plant at the time the sample is taken. Their main value is that they indicate immediate needs of the crop, and the necessary plant nutrients can then be added to the soil. In addition, it can be used to predict the future fertilizer needs of perennial crops such as fruit trees and pastures. But there are certain plant nutrients that are difficult to supply



A color comparator is used in soil and tissue testing. It is less sophisticated than equipment such as the spectrophotometer but gives excellent results when used properly.

to growing plants, notably phosphorus, because they do not move far from the point of application in the soil. This would indicate that plant analysis is not the complete answer to determining plant requirements.

Nutrient Deficiency

Nutrient deficiency symptoms, also called "hunger signs," provide striking evidence that something is lacking for satisfactory plant growth. Generally, the symptoms produced by the deficiency of an element essential to plant growth are quite specific for a given species of plant. However, many symptoms are common to many different plants. These symptoms may be used to determine plant needs, but much care must be exercised not to confuse such nutrient deficiency symptoms with damage from insects, diseases, and herbicides. By the time deficiency symptoms are recognized, plant growth is affected to such an extent that yield and quality may be reduced. Some deficiencies may be corrected by applying fertilizers to the soil or as a foliar spray. In most instances, the deficiency symptoms indicate the needs for the subsequent crop.

Soil Testing

Soil testing is a means of determining the level of extractable nutrients in the soil. The results of these tests, together with a knowledge of the

Nutrient deficiency symptoms are indicators of plant needs. Each nutrient deficiency shows as distinctive patterns and colors on certain parts of the plant for each crop. This citrus tree shows the typical symptoms of severe zinc deficiency.

characteristics, past management, and performance records of the soil, and the knowledge of the crop and its needs serve as a basis for fertility management recommendations for the crop on these soils. Soil testing can be an effective method for determining the fertility needs before the crop is planted. Soil tests are valuable in "trouble shooting" or identifying the deficiency or toxicity of elements in a minimum period of time or with a minimum loss in crop yields. Soil tests are most effective when used in conjunction with other methods.

There are many different ways to classify soil tests. For this discussion soil tests are classified as total analysis, partial analysis, and quick testing. Total analysis determines the total supply of all plant nutrients present in the soil. The analysis may be done by chemical or chemical-physical means. Total analysis does not indicate availability of nutrients to the plant and for this reason has limited value for recommending soil management practices. However, it is valuable as a research tool and is used extensively in the characterization of soil.

Partial analysis is similar to total analysis, except it is used for only one or more of the nutrients in the soil. This method of analysis has the same limitations as total analysis for making fertility management recommendations.

Quick Testing

Quick testing, known as the rapid chemical method (RCM) in Hawaii, is an abbreviated analysis to determine soluble nutrients in the soil. It determines the amounts of plant nutrients that are dissolved in the particular extracting solution used. The major difference in the various systems of quick testing is the extracting solution used. The extracting solution usually consists of a relatively weak acid, base or neutral salt for removing the extractable plant nutrients.[1] By shaking the extracting solution with the soil, chemical reactions may occur be-

[1]The extracting solution used in the University of Hawaii soil testing laboratory, at the present time, is 0.3 N Hydrochloric acid.

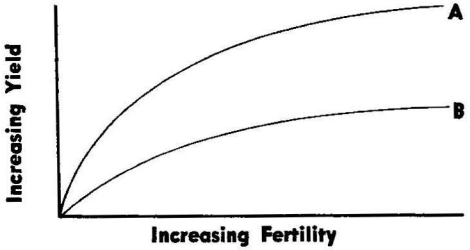


Figure 1. Yield curves for plants. A is the potential yield under completely controlled conditions. B is actual yield due to effect of weather, insects, disease, low fertility, etc. Field tests, pot tests, soil and plant analyses are used to bring curve B as near curve A as possible.

tween the soil and the extracting solution. The soil is then filtered to separate the solution. As the solution is filtered, the nutrients that have been removed from the soil pass through with the solution and the concentrations of these nutrients can be determined by a series of tests. The amount of each nutrient removed by the extracting solution depends upon the type of extractant, the strength of the extractant, the length of time the extractant remains in contact with the soil, the type of soil, and the form in which the nutrient occurs in the soil.

The amount of nutrient extracted from the soil usually does not represent the total amount actually present in the soil. Only a fraction is removed in the extracting solution and this amount may not represent exactly that which is available to the plant. No claim is made that the test is able to duplicate the plant so closely that it can remove in a few minutes by chemical extraction what the plant will remove during its growing season. Therefore, it is necessary to correlate test results with the relationship between the amount of nutrient extracted, the soil conditions, the climatic conditions, and the yield of the crop obtained. Correlation involves a great number of fertilizer trials and soil tests made on many different soil types for each crop. Much effort by many different people is required before the fertility needs can be accurately predicted by this type of soil testing. All other methods of determining nutritional needs also require this type of correlation before they can be used to accurately predict fertility needs.

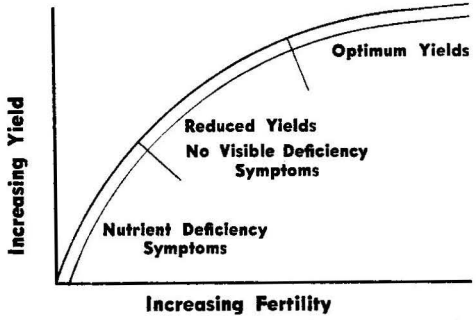


Figure 2. Relationship of yield curve to supply of plant nutrients in the soil. (After the American Potash Institute)

Soil Test Results

Soil test results in Hawaii are reported as pounds per acre.[2] These are then interpreted as very low, low, moderate, high, or very high, based upon the results of the correlation work with the soil and the crop. Very low and low test results indicate that nutrient deficiency will occur and that fertilizers are needed for all crops under all conditions. Most of the nutrients needed by the plant must be supplied by adding fertilizers. Very high and high tests generally indicate

[2]Elsewhere test results are sometimes reported in parts per million.

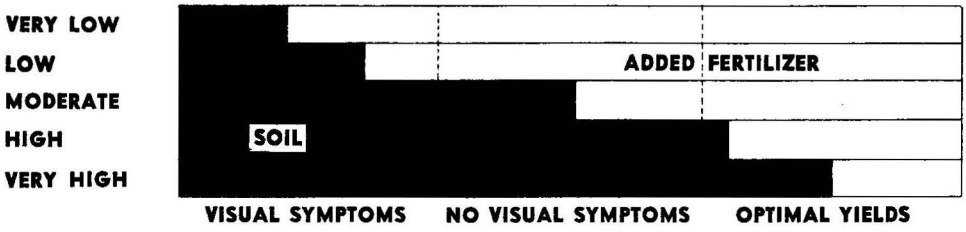


Figure 3. Relationship of plant growth and nutrient uptake as related to the soil test. The shaded area represents the nutrients supplied by the soil and the unshaded area the amount taken from the added fertilizer. There is a definite need for fertilizer at the very low and low levels, but little need at the high and very high levels.

an adequate supply of nutrients under most conditions. Only a small amount of the nutrients needed by the plant will be taken from the added fertilizer. Intermediate tests are not as easily interpreted.

Nutrients Tested

Tests have been developed for all of the elements essential to plant growth. However, many of the tests require special techniques that are not adaptable to routine analysis and many have not been refined to the stage where critical levels of the nutrient can be determined. For this reason tests for only a limited number of elements are made. These include tests for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). No test is made for nitrogen at the University of Hawaii due to the rapid fluctuations in the nitrogen supply in tropical soils. Further tests may be made for pH (acidity or alkalinity) and electrical conductivity (salinity).

The pH test is one of the most valuable soil tests since pH has important effects on the availability of plant nutrients in the soil. It is used as a guide for the need for lime (any form of calcium and magnesium used to neutralize the acidity of the soil) to correct unsatisfactory growing conditions for the plant. The conductivity test is made to determine the level of soluble salts in the soil as these salts may adversely affect the growth of plants.

The soil test is a measure of the extractable nutrients in the soil. It does not indicate physical conditions in the soil, weather conditions, moisture supply, effects of disease, insects or herbicides, etc. For this reason when soil samples are submitted for testing a soil record sheet (Cooperative Extension Service Form 312) should be submitted providing needed supplemental information. These soil tests do not indicate what to plant nor when to plant. They indicate only the extractable nutrients in the soil as a guide to recommending fertilizer practices for the crop to be grown. Soil testing is a free service offered by the College of Tropical Agriculture. For help in taking soil samples, for soil record sheets (Form 312), and for assistance in submitting soil samples, contact your local County Extension Agent. Don't guess, soil test!

Pointers on Tests for Soil Fertility

1. Soil tests give no information regarding the effect of important physical factors, disease, insects, water supply, drainage, system of cultivation, temperature, and seasonal variations.
2. Soil tests are designed to indicate the availability of phosphorus, potassium, calcium, and magnesium from a particular soil.
3. Plant analysis show the relative nutrient supply as compared to other possible limiting factors. The results apply only to the conditions under which plants have been grown.
4. A coordinated system of testing that gives a complete picture of the nutrient status of both plant and soil is more valuable than a single test system for any one nutrient.
5. It is not possible to have a general interpretation of test results, applicable to all crops, at all yield levels, and for all soil and climatic conditions. In practical interpretations, full consideration should be given to other plant growth factors. The appearance of the plant is often of much assistance. Certainly soil type, water supply, and other physical factors that influence fertilizer efficiency and potential productivity must be considered.
6. The tests serve as good indicators of the type of fertilizer that can profitably be used, that is, whether the fertilizer should be high in phosphorus or potassium or in some combination of these nutrients. For a definite recommendation, findings from the tests should be weighed with the general knowledge as to amount of fertilizer and time and method of application found profitable for different crops and soils. For this reason field plot and pot tests should be made wherever possible. Field plot tests continued over a long period of time are especially valuable in showing the cumulative effects of fertilizer and other treatments under the various natural conditions that influence crop yields.
7. In general, with the soil and plant tests described in this circular, very low results for any nutrient indicate a definite need for all crops under practically all conditions and very high tests indicate an adequate supply. Intermediate tests are not so easily and so definitely interpreted. Except in extreme cases, no crop production factor should be considered alone but only in its relation to other factors.

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